Social perspectives on climate change adaptation, sustainable development, and artificial snow production: a Swiss case study using Q methodology

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Social Perspectives on Climate Change Adaptation, Sustainable Development, and Artificial Snow Production: A Swiss Case Study using Q Methodology

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Author Declaration

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We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

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Highlights

- Three distinct groups are identified amongst diverse cross-sector stakeholders based on their specific social perspectives.
- Q methodology revealed broad value consensus even among divergent stakeholders.
- Consensus finding is hindered by polarized stakeholder views on tourism development.
- Relying solely on snowmaking as a climate change adaptation strategy is unsustainable.
- Nuances in stakeholder attitudes and value systems may undermine climate change adaptation if not fully recognised.

Abstract

Climate change has reduced the snow cover in the Swiss Alps, negatively impacting the winter tourist sector. The adaptation of artificial or technical snow, as a solution to combat a decline in tourism, is pervasive, yet controversial. This paper uses Q methodology to analyse the perspectives of stakeholders in relation to artificial snow production with regard to the three pillars of sustainable development. While all stakeholders agreed that there are ecological constraints to socioeconomic development, three distinct perspectives were identified. Perspective 1 prioritizes the environment, not accepting ecological compromises for socioeconomic development. Perspective 2 is more willing to accept trade-offs, focusing on economic diversification and long-term strategies. Perspective 3 focuses on the economy, with a preference for the status quo. The ecological awareness of all stakeholders provides a promising basis for sustainable development. However, the diverse views on priority setting present nontrivial obstacles towards devising future strategies for sustainable development.

1. Introduction

The global climate crisis is threatening the viability of winter tourism. This fuels a heated controversy over how to best support continued tourism in mountainous regions. The strength of opinion is motivated on the one hand by significant concerns of the environmental impact of some technological options that communities have at their disposal (like Artificial Snow Production – ASP), and on the other by the overall threat posed to rural areas by urbanization and the associated outmigration of young people (Bundesamt für Raumentwicklung ARE, 2012). With its combination of mountain rural agriculture economy, an important winter tourism economy, and on-going urbanisation, Switzerland is a model country to study the ongoing controversy over how to sustainably maintain mountain tourism in a warming world.

Central to the nature of this controversy is the range of perspectives that drive the behaviour and choices of stakeholders in relation to winter tourism and ASP, yet little research has been conducted to provide a detailed understanding of these perspectives (see ‘ Background and Motivation for Using Q Methodology' in the SI). This paper responds to this research gap. Swiss stakeholder perspectives are analysed qualitatively and quantitatively in relation to ASP[1], one of the most controversial mountain region development topics with respect to winter tourism (Fueter, 2013). The value of this approach stems from its characterisation of the degree of polarisation and consensus present amongst stakeholders. The insights presented serve future policy design and consensus building efforts focused on sustainable mountain tourism in Switzerland.

1.1 Climate Change, Artificial Snow Production, and Sustainable Development

The tourism sector is the sixth largest Swiss export industry, providing 4.3% of jobs (Matasci, 2012; SWI, 2017). The economy in the Swiss mountain regions has for decades depended specifically on winter tourism and the cableways industry (OECD, 1995; König and Abegg, 1997; Bürki et al., 2005). In many places, more than 80% of their income is generated during the winter season (Stünzi, 2015; STV, 2016; OcCC, 2007). Climate change, however, has already impacted the Swiss winter tourism industry. Warming temperatures began to negatively affect the industry in the late 80’s causing a 20% decrease in cable-way earnings at lower altitudes (Elsasser and Bürki, 2002), and may be responsible for the 18% decline over the past 10 years (2008 - 2018) of the five-year average of skier days per season in Switzerland (SBS, 2018; Vanat, 2019).

The continued effects of climate change on tourism in the Swiss Alps will be mixed. One the one hand, climate change is likely to undermine winter tourism: projections suggest that by 2050 the snowline will retreat another 350 meters, and that overall winter precipitation will decline (OcCC, 2007; Schmucki et al., 2017). Decreasing future precipitation rates in the Alps (Schmucki et al., 2017) will also complicate the spatio-temporal distributional consequences of water allocation policies in the Swiss mountains (Viviroli and Weingartner, 2002; Viviroli et al., 2003). Consequently the importance of winter tourism will decline without intervention. On the other hand,

[1] The distinction between different terminologies for ASP (including ‘man-made’, ‘artificial’ and ‘technical’ snow) matters to some individuals while not to others. This study treated “ASP” as synonymous to alternative terms under the assumption that stakeholders would vocalize their opinion on this matter if it truly mattered to them. See SI Table 5.

however, Swiss towns may find they are substitutes for German and Austrian locations experiencing even more extreme changes (Elsasser and Bürki, 2002; Gonseth, 2013; Gonseth and Vielle 2012; Ehmer and Haymann, 2008). Any such effect will, to an extent, counterbalance the decline in Swiss winter tourism caused by climate change.

To both hedge against Swiss environmental change, and to capitalize on faster changes in other locations, the Swiss have attempted to adapt to the challenges of climate change by investing in ASP (Vanat, 2017; Rixen et al., 2011; Elsasser & Messerli, 2001). However, the practice is a tenuous one financially. The annual income of the Swiss cableways of approximately CHF 900 million (STV, 2016; SBS, 2016b) is juxtaposed with the annual operational costs for artificial snowmaking of CHF 165-275 million (Iseli, 2015; SBS, 2016a).

ASP is also controversial environmentally. It is currently energy intensive,[2] uses significant quantities of water, [3] affects alpine environments,[4] and increases flood risks in lower elevation regions (Rixen, 2008; Fueter, 2013; Pütz et al., 2011; Hamberger and Doering, 2015; Hudson, 1996; Pröbstl, 2006; SLF, 2002; Pröbstl, 2006; Teich et al., 2007).

Socially, the discourse on ASP is characterised by a degree of cognitive dissonance. Several surveys show that many people firmly believe climate change is real and human beings are fully responsible for the rising temperatures (Tobler et al., 2012; AXA/IPSOS, 2012; Lorenzoni and Pidgeon, 2006). However, as recently as 2006, the problem was viewed by many as a foreign rather than a domestic one (Lorenzoni and Pidegon, 2006). Furthermore, winter tourism remains culturally significant in Switzerland (Vanat, 2017), suggesting there may be a cultural reluctance to de-emphasize winter sports. As such, ASP remains the dominant adaptation strategy to combat the effects of climate change in the Alps (Abegg et al., 2007; de Jong, 2007; Steiger et al., 2017), despite also contributing to it.

Thus, in terms of contributing to all three pillars of sustainable development – a concept formally adopted by the Swiss Government (ISDC, 2012) - the use of ASP is complicated. Although a diversification strategy emphasizing summer tourism and de-emphasizing ASP is gaining increasing attention (de Jong, 2009; Müller, 2011; Miller, 2017) and may facilitate sustainable development, it cannot be pursued without the alignment of stakeholders in relation to major controversial issues. In turn, this implies a need to understand the diversity of attitudes that exist regarding ASP. Therefore, this paper analyses Swiss stakeholder perspectives on subjects ranging from specific aspects of ASP to the bigger picture of sustainable development and changes in behaviour to adapt to, or combat climate change.

2. Methods

Q methodology seeks to uncover subjective viewpoints using a variety of key stakeholders (i.e. the variables) and a sample of opinion statements (i.e. the subjects) from the population of opinions that exist in relation to the topic of interest (Webler et al., 2009; Herrington and Coogan, 2011). Q methodology minimizes researcher interference in the expression of opinions by participants. For a deeper explanation of Q methodology and the motivations for its use in this context, see the SI. Q methodology consists of five steps as described previously (Webler et al., 2009; Watts and Stenner, 2012; Kitzinger, 1999; Curt, 1994; Stephenson, 1993; Brown, 1980; Brown, 1993; Stainton Rogers, 1995). Briefly, participants rank statements according to their strength of opinion about those statements, and this enables the unveiling of unique social perspectives both quantitatively, using factor analysis, and qualitatively using thematic and/or content analysis (Brown, 1996). Q produces distinct subgroups of the investigated population according to their respective unique social perspectives.

[2] Electricity use for ASP in Davos, one of the largest Swiss ski resorts, was ~1.7 million kWh in 2006/2007. This was ~25% of the total electricity consumption by the Davos cableways (Rixen et al., 2011), and ~250 times the per capita annual Swiss electricity consumption (UVEK, 2016). Technological development is reducing the energy consumption of snow canons: some models are now powered by water pressure alone (Bächler Top Track AG, 2017).

[3] Currently, up to 14 million m^3 of water are used per winter season: more than the annual water use of Bern, the capital of Switzerland (Iseli, 2015). Water consumption increases year by year, as artificial snow production expands.

[4] Beyond reducing water levels in alpine lakes, artificial snow sometimes contains nitrates to lower the melting point of snow (SLF, 2002; Rixen et al., 2004; Wipf et al., 2005; Schwörer et al., 2007). These have an impact on the vegetation and on the water ecology (Rixen, 2008). ASP also protects mountain vegetation from mechanical damage by snow groomers and skiers (Teich et al., 2007; Roux-Fouillet et al., 2011), and from frost and extreme temperature changes (Rixen et al., 2004). In addition, ASP eliminates the need of “snow collection” from regions next to the slope, thereby reducing damage to the vegetation by shovelling activities (Pröbstl, 2006).

As per standard procedures, a concourse, defined as the full opinion spectrum in relation to a topic, was established by using an inductive, exploratory research strategy to retrieve statements related to ASP. A conscious decision was made to prioritize Swiss-based information. Statements were obtained, in both English and German, from Social Media (e.g. Facebook), Swiss News Media Outlets (e.g. Swissinfo, Tages-anzeiger), and previous works (website, peer-reviewed and working papers) provided by the Institute for Snow and Avalanche Research (SLF) and its parent institute, the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL). Since the SLF and WSL are the leading research institutes in Switzerland on ASP, their list of publications were used as an effective database to obtain statements. The domain of subjectivity focused on issues pertaining to ASP, ecological concerns, economics, and sustainability.

Following the statement-collection process, the concourse of 81 statements was reduced to a set of 58 statements (see SI: Q-set) which represented the broad scope of the concourse. The Q-set was created in English and German to accommodate participant linguistic preferences. A forced-choice distribution grid (FCDG), consisting of an 11-point scale ranging from -5 ('least like I think') to + 5 ('most like I think') was used (SI Figure 1).

A purposeful sampling recruitment strategy, selecting knowledgeable German or English speaking stakeholders within the German-speaking part of Switzerland, whose viewpoints were defined, relevant and informative, was used to establish the P-set (i.e. the list of participants) and to ensure that the key stakeholder groups were targeted (Marshall, 1996; Webler et al., 2009). In total, 31 participants were interviewed: Academics (8), Businesses (12), NGOs (2), Government employees and Politicians (6), a National Winter-Sports Organisation (1), a Private Non-Profit Organization working closely with the Government (1), and a public-private organization working closely with the Swiss Tourist Board (1). Business comprises of both Ski industry, i.e. all goods and services provided for ski activities (11), and Farmer's Association (1).

Interviews were conducted on a face-to-face basis during the summer of 2017. The participants were given the Q-set and were instructed to read the statements carefully. The researcher stated that the aim was to obtain their opinions on ASP, and that the Q-sorting was not a test of their knowledge. The participants were asked to complete either side of the FCDG with its range from -5 to +5, before filling the middle of the grid.

The transition between statements viewed positively, neutrally, and negatively was recorded as this enabled the researcher to better assess where participants' negative/positive feelings began (Watts and Stenner, 2012). After the grid was completed, participants were asked to elaborate on the meaning behind the statements placed in the +/- 5 columns.

2.1 Data Analysis

The quantitative analysis was conducted in R, using the package 'qmethod' (version 1.5.4 – see SI for the code) (Zabala, 2014). The analysis used Principle Component Analysis (PCA) in order to extract from the individual viewpoints, represented by the Q-sorts, a finite number of broad social perspectives (i.e. factors). The various stakeholder perspectives on ASP were uncovered using an inductive factor extraction strategy (Watts and Stenner, 2012, p.95). The final factor solution was selected based on both quantitative metrics, and a thematic analysis of the interview transcripts with respect to certain themes, including water use, energy use, ecological concerns, diversification, and economics.

3. Results

3.1 Quantitative Results

A 3-Factor solution was used since it satisfied the following quantitative metrics (SI – Full Results) and produced coherent qualitative discourses.

- Cattell's scree test (Cattell, 1966; see SI Figure 2)
- Humphrey's Rule (Watts and Stenner, 2012)
- Kaiser-Guttman criterion (Guttman, 1954; Kaiser, 1960; Kaiser, 1970)
- A minimum of 2 Q-sorts that significantly load on each factor (Watts and Stenner, 2012)

Of the 31 Q-sorts, 9 loaded significantly onto each of the factors (Table 1, SI Table 1). The remaining Q-sorts did not load significantly onto any of the factors. Consequently, these sorts played no role in the development of discourses because they did not clearly define any of the unique social perspectives that emerged from the data.

Table 1 – Significantly loaded Q-sorts that represent each factor including sector of employment & factor loadings.

Defining Q-sorts including sector of employment		**Factor A**	**Factor B**	**Factor C**
Social Perspective A: Conservative Ecologist				
Stakeholder02	Academic	0.7602	0.2906	0.1449
Stakeholder05	Academic	0.8881	-0.0332	-0.0603
Stakeholder07	Academic	0.7212	0.3533	0.1806
Stakeholder21	NGO	0.8639	-0.1043	0.0926
Stakeholder22	NGO	0.8850	-0.1694	0.1334
Stakeholder24	Private non-profit	0.8055	-0.0778	0.2524
Stakeholder25	Politician	0.8079	-0.0557	-0.1690
Stakeholder27	Government	0.7829	0.0912	-0.1310
Stakeholder28	Government	0.7161	0.2761	0.2808
Social Perspective B: Universalists				
Stakeholder09	Business	-0.0698	0.6848	0.1277
Stakeholder10	Business	0.0403	0.5564	0.5374
Stakeholder15	Business	-0.3504	0.5890	0.3048
Stakeholder17	Business	-0.1627	0.4737	0.3982
Stakeholder19	Business	0.2203	0.6799	-0.0237
Stakeholder26	Government	0.0956	0.6414	0.2056
Stakeholder29	Government	-0.0014	0.7033	0.1560
Stakeholder30	Government	-0.0688	0.6469	0.4154
Stakeholder31	Business	0.0878	0.6454	0.1350
Social Perspective C: Winter Industry Preservers				
Stakeholder06	Academic	-0.0667	0.3203	0.7263
Stakeholder11	Business	0.1193	0.1110	0.5785
Stakeholder12	National Winter-Sports Organisation	-0.2809	0.2139	0.7607
Stakeholder13	Business	-0.1634	0.4555	0.5482
Stakeholder14	Business	0.2534	0.1117	0.4754
Stakeholder16	Business	0.2844	-0.2211	0.6375
Stakeholder18	Business	0.2293	0.3775	0.4995
Stakeholder20	Business	-0.1330	0.4171	0.6052
Stakeholder23	Public-Private Organization	0.1557	0.4524	0.6318
Non-significantly loading sorts				
Stakeholder01	Academic	0.3436	0.5599	0.4818
Stakeholder03	Academic	0.2378	0.5178	0.5236
Stakeholder04	Academic	0.2603	0.5432	0.5285
Stakeholder08	Academic	0.3932	0.4316	0.4703
Percentage of explained variance (%)		22.03	19.07	17.68
Eigenvalues		6.83	5.91	5.48
Total number of defining Q-sorts per factor		9	9	9

Each of these factors represents a particular, unique social perspective on ASP, and can be represented in the form of a Q-sort that reflects the idealized sort associated with that perspective (SI Figures 3-5). These idealized sorts come from the z-scores associated with each statement-factor combination. The differences between these idealized sorts provide an indication of the extent to which each of these social perspectives is different from each of the others. Quantitatively, the differences between factors are evaluated by considering the pairwise differences in the z-scores for each statement across the idealized sorts for each factor (Table 2). The z-scores are calculated for each factor, for each statement, using the Q-sorts that load significantly onto that factor, and their associated factor loading scores (SI Z-Scores). The degree of statistical distinction between any pair of z-scores is evaluated by determining the distance between the z-scores and comparing that to a significance threshold (that, in turn, is established using the standard deviation of z-scores and a reliability score). This degree of statistical distinction between the factors is the basis for establishing areas of polarization, partial/broad consensus, and true/universal consensus.

Table 2 Idealized Q-sorts and assessment of consensus/polarization[5]; Factor A represents social perspective A; Factor B represents social perspective B; Factor C represents social perspective C

Statement	Factor A		Factor B		Factor C		Significance[2]			Label
#	IQSP[1]	z-score	IQSP	z-score	IQSP	z-score	F1:F2	F2:F3	F1:F3	
1	**1**	0.39	**-4**	-1.46	**-5**	-2.08	****	**	****	Polarized
2	**-3**	-1.04	**1**	0.43	**2**	0.67	****		****	
3	**3**	1.07	**-3**	-1.11	**0**	-0.02	****	***	***	Polarized
4	**-5**	-1.59	**0**	0.02	**1**	0.38	****		****	
5	**4**	1.55	**2**	0.53	**4**	1.72	***	****		
6	**1**	0.44	**-4**	-1.23	**-5**	-1.63	****		****	
7	**0**	0.07	**0**	-0.15	**-2**	-0.62		*	**	
8	**3**	1.16	**1**	0.21	**1**	0.45	***		**	
9	**1**	0.37	**3**	0.79	**2**	0.90			*	Broad Conensus
10	**1**	0.32	**3**	0.84	**5**	2.03	*	****	****	Polarized
11	**0**	-0.25	**4**	1.48	**5**	1.85	****		****	
12	**-1**	-0.33	**1**	0.25	**4**	1.19	*	***	****	Polarized
13	**-3**	-1.06	**1**	0.19	**4**	1.17	****	***	****	Polarized
14	**-2**	-0.68	**4**	1.55	**3**	1.08	****	*	****	Polarized
15	**-2**	-0.85	**2**	0.62	**0**	-0.01	****	**	***	Polarized
16	**-1**	-0.61	**3**	1.30	**3**	1.03	****		****	
17	**-5**	-1.54	**1**	0.30	**-1**	-0.32	****	**	****	Polarized
18	**2**	0.47	**-1**	-0.26	**0**	0.00	**		*	
19	**0**	-0.22	**1**	0.44	**-1**	-0.22	**	**		
20	**-4**	-1.37	**-1**	-0.32	**-2**	-0.67	***		**	
21	**-2**	-0.90	**-2**	-0.91	**-5**	-1.98		***	***	
22	**2**	0.75	**-1**	-0.43	**1**	0.30	****	**		
23	**4**	1.52	**5**	1.76	**3**	1.15		**		Broad Consensus
24	**5**	1.59	**5**	2.07	**0**	0.13	*	****	****	Polarized[3]
25	**2**	1.03	**2**	0.78	**2**	0.66				Consensus
26	**4**	1.54	**5**	1.71	**0**	-0.12		****	****	
27	**0**	0.28	**0**	0.12	**1**	0.42				Consensus
28	**3**	1.31	**3**	1.19	**-1**	-0.36		****	****	
29	**0**	-0.20	**-1**	-0.59	**2**	0.75		****	***	
30	**4**	1.46	**3**	1.39	**5**	1.73				Consensus
31	**2**	0.93	**-4**	-1.42	**0**	-0.06	****	****	***	Polarized
32	**3**	1.19	**-4**	-1.26	**-3**	-0.94	****		****	
33	**-1**	-0.38	**0**	0.16	**-2**	-0.68	*	***		
34	**-3**	-1.07	**0**	0.09	**-2**	-0.60	****	**	*	Polarized
35	**3**	1.32	**-5**	-2.11	**-4**	-1.34	****	***	****	Polarized

[5] Broad consensus points are points of agreement qualitatively, but quantitatively there is evidence that supposes a point of not total agreement. As such, they are not an output from R.

36	**2**	0.70	**-2**	-0.72	**-2**	-0.62	****		****	
37	**-3**	-1.09	**-2**	-1.00	**-1**	-0.23		***	***	
38	**-5**	-1.81	**-2**	-0.78	**-4**	-1.61	***	***		
39	**-2**	-0.89	**-1**	-0.22	**-1**	-0.33	**		*	
40	**5**	1.74	**-2**	-0.70	**-1**	-0.13	****	*	****	Polarized
41	**0**	-0.11	**-3**	-1.16	**1**	0.14	***	****		
42	**-2**	-0.72	**0**	0.09	**-4**	-1.37	***	****	**	Polarized
43	**1**	0.39	**-3**	-1.16	**0**	-0.05	****	****		
44	**-1**	-0.39	**4**	1.49	1	0.58	****	***	***	Polarized
45	**-2**	-0.78	**-3**	-1.08	**-3**	-1.10				Consensus
46	**-1**	-0.42	**4**	1.53	**0**	-0.08	****	****		
47	**-1**	-0.31	**2**	0.48	**3**	1.08	***	**	****	Polarized
48	**2**	0.55	**-2**	-0.85	**2**	0.66	****	****		
49	**1**	0.41	**-5**	-1.53	**-4**	-1.52	****		****	
50	**-1**	-0.68	**-1**	-0.35	**-3**	-1.04		**		Broad Consensus
51	**-4**	-1.47	**0**	0.19	**3**	1.03	****	***	****	Polarized
52	**-4**	-1.47	**2**	0.77	**4**	1.39	****	**	****	Polarized
53	**0**	0.22	**2**	0.50	**-1**	-0.38		***	**	
54	**1**	0.31	**-5**	-1.64	**-3**	-1.15	****	*	****	Polarized
55	**-3**	-1.15	**-3**	-1.04	**-3**	-1.34				Consensus
56	**0**	0.18	**1**	0.45	**2**	0.60				Consensus
57	**-4**	-1.43	**0**	-0.09	**1**	0.23	****		*****	
58	**5**	1.56	**-1**	-0.18	**-2**	-0.73	****	*	****	Polarized

[1] IQSP - Idealized Q-sort position

[2] For any given statement, these columns show the smallest p-value at which the strength of opinion about said statement can be statistically distinguished from the strength of opinion held by the other factors towards that same statement. A lack of symbols indicates the opinion of one factor is indistinguishable from the strength of opinion in another factor. The presence of the '*' indicates some statistically significant differences in the strength of opinion pertaining to a given statement: * indicates p-value <0.05; ** indicates p-value <0.01; *** indicates p-value <0.001; **** indicates p-value <0.000001.

[3]While WIPS essentially agree to a diversification strategy (summer tourism etc.), they are the least enthusiastic group to embrace this measure. Therefore, we kept the R produced output of 'polarized'.

3.2 Qualitative Results

Q methodology revealed 3 factors, to which individual stakeholders were assigned based on their quantitative responses. Based on the qualitative responses characterising each stakeholder group, the following 3 group labels were assigned: A) Conservative Ecologists, B) Universalists, and C) Winter Industry Preservers (WIPS). Interview quotes are located in SI Tables 2-4, respectively. SI Table 6 summarizes participants' priority rankings of the following three concerns associated with ASP: high water consumption, high electricity consumption, and vegetation degradation.

Social Perspective 1: Conservative Ecologists

This perspective accounts for 22% of the study variance, and is held by the stakeholder group termed Conservative Ecologists who prioritize the ecology over the economy. The common thread among these participants is that their professional orientation is geared towards the ecology. In other words, the Q-sorts that loaded onto factor 1 were conducted by participants who either work for 1) a governmental and/or non-governmental environmental organization geared to protect the ecological status-quo, 2) the Green Political Party or 3) they are academics who focus on ecological aspects such as alpine vegetation or hydrology. Even the sole economist (Stakeholder05) who loaded significantly onto factor 1 works at an environmental institute.

Conservative Ecologists view ASP as an inappropriate economic strategy for the short, medium, and long run for all ski resorts, including high altitude ski resorts (S2 -3; S8 +3). They believe resorts should not invest in snowmaking given the declining skiing demand (S6 +1). They reject any economic justification for ASP, including potential economic losses to mountain railways and hotels (S11 0), as well as any 'false' sense of obligation towards skiers who travel to ski (S16 -1). Moreover, they are concerned that ASP costs will increase ski prices to the point that only the wealthy can ski (S18 +2). Also, they more strongly dislike a unilateral decision-making system (S39 -2), preferring an inclusive, bottom-up approach (S20 -4).

Concerns over loss of fragile alpine vegetation and changing biodiversity, even under restricted use of chemical additives, is another element of the negative attitude of Conservative Ecologists towards ASP (S32 +3; S4 -5). Additionally, Conservative Ecologists are concerned about soil erosion and an increasing likelihood of mudslides, as artificial snow is more compact and contains more water than natural snow (S36 +2). Even if no electricity is required for snowmaking, as advertised for the technologically advanced Nessy ZeroE (Bächler Top Track AG, 2017), Conservative Ecologists would still not support ASP (S49 +1).

Furthermore, Conservative Ecologists perceived the current governmental regulations as a necessity rather than as excessively restrictive (S57 -4). Their attitude mirrors their strong adherence to the precautionary principle, which in Switzerland is an integral part of governmental ASP approval processes (Amt für Natur und Umwelt, 1991).

Social Perspective 2: Universalists

This social perspective accounts for 19% of the study variance, and is characterised primarily by the value to maintain a balanced approach towards problems. The 'quintessential' Universalist views any socio-economic development as permissible if it is compatible with already established ecological conservation policies and principles in Switzerland.

Governmental tourism departments, businesses and the transport industry are represented in this social perspective, which indicates their desire to think holistically yet strategically. They have a longer time horizon in mind when discussing the topic of ASP, relative to the other two discourses.

Universalists reject preconceived notions and a tunnel vision mentality, as these do not foster forward-thinking strategy or policy formation (S22 -1). They deem the application of universal rules

regarding ASP use as inappropriate (S41 -3). Scepticism towards generalist approaches distinguishes Universalists from both the Conservative Ecologists and WIPS, including with respect to their concern about preferring any one natural resource over the other, such as water over electricity (S43 -3), and simplistic universal snowmaking rules (S5 +2).

Although Universalists are in favour of promoting year-round tourism and diversification (S24 +5), they do not appreciate simplistic arguments (i.e. anti-winter tourism arguments (S22 -1), uncritical conservation arguments (S35 -5; S48 -2), and uncritical development arguments (S26 +5)). The general opinion of Universalists about ASP is that it preserves the winter tourist industry, which is part of Switzerland's general tourism profile. Therefore, it should not be reduced unless there is a considerable hindrance towards achieving socio-economic and ecological goals. Instead of either outright rejecting or accepting ASP, the quintessential Universalist supports the consideration of all social, cultural, economic, and ecological issues within the formulation of a multi-pronged, site-specific sustainability strategy (S23 +5).

An exemplary attitude which defines their unique, balanced social perspective is their strong willingness to agree to the statement that snow cannons are widely accepted presently because the impact on the environment has not been as damaging as expected, and because there are strict regulations on using local water resources (S46 +4).

Social perspective 3: Winter Industry Preservers

This last social perspective accounts for 17% of the study variance, and is held by businesses and organizations which wish to preserve the winter tourist industry. These include winter sports businesses, as well as the transport, the hotel, and the agriculture industry.

Winter Industry Preservers (WIPS) exhibit pragmatic, business minded thinking and display considerable scepticism towards theoretical or ideological approaches. Therefore, they are often defensive in their answers, although they understand ecological considerations and the inevitable need to diversify and innovate. Despite this, preserving the mountain tourism industry is a non-negotiable priority, and preservation is preferred to diversification.

WIPS' attitudes are reflected in their response to S26 (0) and S21 (-5): they exhibit a seemingly neutral stance towards 26 (i.e. having a profound site-specific understanding of visitors' attitudes is more important that simply reverting to ASP), while strongly favouring the need to innovate constantly to remain competitive within the market for as long as tourists keep coming.

Although WIPS acknowledge ecological concerns, they tend to be more economically focused, which ultimately determines their positive attitude towards ASP as a means to preserve the status-quo. They strongly favour economic justification for ASP (S11 +5; S10 +5). Despite their approval of S30 (i.e. that resorts should not count on snowmaking alone to adapt to climate change), the 'no snow no guests' adage remains salient for them.

The most defining characteristic of WIPS is their view on employment, and specifically, that boosting the winter tourist industry is and will continue to supply more jobs than could diversifying into summer activities (S29 +2). WIPS consider this a given fact, whereas Conservative Ecologists and Universalists are more optimistic about the potential for diversification to provide employment. It is primarily on this basis that WIPS justify their opinion regarding the essentialness of ASP.

3.3 Consensus Points & Areas of Polarization

3.3.1 Points of Consensus

The results reveal six true and three broad consensus points (Table 2). All social perspectives agree that:

- It is not wise for every ski resort to invest heavily in ASP (S25)
- Resorts should not rely solely on snowmaking as an adaptive strategy towards climate change (S30)
- Skiing is a profitable business, its economic importance is vital to rural mountain areas, and no single source of income could replace skiing financially (S27)
- Just because ASP is important to the skiing industry, it should not be allowed to negatively impact water allocation to other sectors, particularly the agricultural sector (S45)
- The economic argument cannot be stretched to the point of performing ASP under almost summer-like conditions (S55)
- Snow farming could potentially reduce ASP efforts and should thus be evaluated as an alternative method (S56)[6]

A broad, but not true consensus was reached with respect to the following ideas:

- Switzerland would suffer the least of ski nations in the Alps with respect to a decrease of snow (S9)
- Attention should be given to site specific strengths to foster a more unique and diverse landscape of activities (S23)
- ASP should not be used for saving even the famous Morteratsch glacier, regardless of motivation (S50)

3.3.2 Points of Polarization

There are 20 points on which polarization was found (Table 2). There are a number of ways to analyse those statements for which each social perspective is distinct from the other two.

Firstly, one can consider the overall degree of relative polarization revealed by the location of these statements in the idealized Q-sorts for each social perspective. The 'number of steps' between the two idealized sorts with the most extreme placement for any statement provides a qualitative indication of the extent to which the factor exemplars for the discourses differ in terms of their perception of that statement relative to all the others in the Q-set. Given the 11-point scale in the FCDG, the maximum number of steps any one statement can be from another once sorted is 10. The mean number in our data is 5.7, and the largest (applying to S35 and S52) is 8. These observations suggest that although there are statistically significant differences in the z-scores for ~42% of the statements in the Q-set, implying the existence of divergent opinions when specific issues are treated in isolation, there are still some similarities in the relative ranking of these statements when the topic of ASP is considered holistically. Consideration of the maximum difference in ranking per statement also suggests that the relative extent of polarization is moderate rather than extreme.

Secondly, one can identify those social perspectives that are most (and least) involved in the instances of relative polarization. This was done by looking at instances where the idealized sort associated with each social perspective ranked statements similarly (i.e. within +/- 1 of each other). The social perspective associated with the Conservative Ecologists and that associated with the Universalists 'sided' together for 2 statements (S12, S24). The Universalists and WIPS 'sided' together

[6] Snow-farming is a technique in which snow is stored to be used for the next season, thereby potentially reducing ASP efforts (Stephens, 2008).

for 6 statements (S1, S14, S17, S35, S47, S58). The Conservative Ecologists and WIPS 'sided' together for 1 statement (S34). The implication of the imbalance between the number of instances when different stakeholder groups 'sided' together is as follows: when considering the issue of ASP holistically, there appears to be more potential for finding areas of consensus/understanding between the Universalists and WIPS than between either stakeholder group and the Conservative Ecologists (though there may be a little more foundation for consensus building between Conservative Ecologists and WIPS than would otherwise be suggested by Table 2).

It's thirdly possible to consider the statements about which there is disagreement, but regarding which no social perspective displayed especially large relative rankings. There are 4 distinguishing statements for which none of the idealized sorts associated with the social perspectives feature a ranking of +/- 4 or +/-5 (S3, S15, S34, S47). Additionally, for 3 of these statements (S3 – focused on short-term investment, S15 – focused on skier willingness to pay for ASP, S34 – focused on how ASP can protect vegetation that might otherwise be exposed to damage) one of the social perspectives has a relatively neutral opinion. Thus, it is possible that these statements signal areas that might have reasonable potential for compromise beyond the areas of consensus discussed in 3.3.1.

There are 16 statements (S1, S10, S12, S13, S14, S17, S24, S31, S35, S40, S42, S44, S51, S52, S54, S58) given a +/- 4 or +/-5 ranking in at least one of the idealized sorts. Of these, there are 5 instances (S1, S12, S17, S24, S44) in which the idealized sort(s) for the social perspective(s) that did not give the statement an extreme ranking gave it a ranking that indicated relative neutrality towards the statement (i.e. -1/0/+1). These statements are suggestive of areas where collaboration between the different stakeholder groups would not necessarily require difficult compromises. For instance, S24 suggests WIPS would not strongly object to considering diversification (which Universalists and Conservative Ecologists feel strongly about), and S17 suggests that neither Universalists nor WIPS are especially attached to using 'social acceptance' of ASP as a justification for its continued use (something that Conservative Ecologists object strongly to).

There are 2 statements (S10, S42) for which the relative ranking differs across the social perspectives, but for which the qualitative signal is similar (i.e. all neutral to positive or all neutral to negative). All social perspectives agree there is some degree of reliance by winter economies on ASP (S10), and none of the social perspectives contend that there is no need to be concerned with water use in ASP (S42).

As mentioned above, however, there are 6 statements (S13, S35, S40, S51, S52, S58) that indicate subjects about which at least two of the social perspectives are essentially diametrically opposed to one another. Thematically, these areas of diametric opposite centre around 1) the extent to which ASP is truly fundamental to mountain economies (S13, S51); 2) the extent to which ASP can be considered as an adaptive measure rather than an excuse to expand development (S40, S58); 3) whether it is acceptable to exclude consideration of either the environmental or socio-economic concerns from the decision-making process surrounding ASP use (S35, S52). These areas are likely to be the most significant barriers to consensus-building and may need to be specifically and comprehensively addressed as a part of a consultative decision-making process. For example, overcoming the barrier represented by divergent opinions about the extent to which ASP is fundamental to mountain economies - especially in the face of the significant uncertainty posed by climate change - may require an emphasis on procedural justice (a contribution to which could be a formal analysis both on the current dependencies and on the economic potential of diversification scenarios that explicitly acknowledges the diversity of opinion/concern on this issue).

4. Discussion

Sustainable development of rural mountain regions provides numerous challenges and ultimately hinges on successful alignment of stakeholders' interests. The aim of this research was to analyse stakeholder perspectives on one of the most controversial topics in mountain development, ASP, in order to determine major similarities and differences in values and attitudes. The results of this study provide the basis for rational communication of the stakeholders' positions, and thereby for constructive discourse and solution finding. To our knowledge, this is the first time Q methodology has been used to analyse ASP and its implications in Switzerland.

In this study, three groups are identified amongst diverse cross-sector stakeholders that can be distinguished based on their specific social perspectives. According to their perspectives the groups were termed Conservative Ecologists, Universalists, and Winter Industry Preservers (WIPS). Interestingly, sector of employment was not a distinguishing factor. For example, businesses are represented in both groups, WIPS and Universalists.

The first important outcome of this work is that there are clear points of true and broad consensus (3.3.1) between the social perspectives of different stakeholders. This is notable given that concerns over ASP are sometimes represented as if the different stakeholder groups were deeply polarized with no common ground from which to operate (e.g. Fueter, 2013). These areas of consensus can serve as a starting place for developing inclusive strategies for sustainable development in the face of climate change. In brief, these are:

- The importance of sustainability (as a multi-faceted, but general concept including inter-generational justice and ecological constraints on socio-economic development)
- Support for practicing common sense
- Agreement that Switzerland has a competitive advantage over its European neighbours in the context of winter tourism and climate change
- A belief that development strategies must be location-specific

Within these points, it's important to recognise:

- The reservations of Conservative Ecologists in relation to the above competitive advantage, given their concern over an increasing need for ASP in the face of decreasing alpine water supplies with climate change
- The reservations of WIPS in relation to an over-emphasis on diversification
- While all three social perspectives value sustainability, they sometimes attach different substantive meanings to more specific sustainability principles

These points of nuance within areas of consensus have the potential to complicate policy development. Consider the last bullet point. All the social perspectives recognise the importance of sustainability, suggesting that sector stakeholders are well-primed to engage with the Swiss Federal Council's 'weak sustainability plus' development strategy (ISDC, 2012, p.12). However, the differences in the substantive interpretation of important sustainability principles, and the pathways to best apply them, could serve as a barrier to developing and implementing specific sustainable development plans. This can be seen in relation to the sustainability concept of inter-generational justice: while the Conservative Ecologists value ecology the most, believing a preservation of nature is the best way to ensure inter-generational justice, WIPS value the economy, stressing the importance of job creation to sustain economic growth as a means to ensure inter-generational justice. Hence, Conservative Ecologists believe policies should be dictated by ecology, while WIPS place particular value on neoclassical growth model principles. In contrast to the above two social

perspectives, Universalists see inter-generational justice in the balancing of all three dimensions of sustainable development. With these different pathways to achieving different versions of the same shared goal (i.e. inter-generational justice) comes a different willingness to incur trade-offs between the three pillars of sustainability. This illustrates that simply having a starting point of consensus would not be sufficient, in and of itself, to produce a specific shared policy vision.

The second important outcome of this work is clear evidence that, although there are points of true/broad consensus between these social perspectives, there are many more points of partial disagreement and polarization between the social perspectives featured in the data. This combination of nuance within areas of consensus, and extended areas of disagreement, suggests that any effort to achieve sustainable development will require engaging with all three social perspectives in a way that is perceived by stakeholders to be procedurally and socially legitimate. Such an effort may hinge on decision-makers' (Pütz et al., 2011; Müller, 2011):

- demonstrating an accurate understanding of the attitudes and value systems that govern all three social perspectives,
- building trust with and between stakeholders, and
- intentionally emphasizing (and fostering) areas of common ground.

If such an approach is not taken, and instead for example, an overly simplistic approach to characterising social perspectives is adopted, it would risk inadvertently focusing stakeholders on the aspects of current polarization. WIPS especially seem likely to feel provoked when their motivations are caricatured as being purely profit-driven (S1), as opposed to having underpinning logic and being driven by the need for a short-run solution while alternative long-term solutions are being developed. Importantly, individuals holding the WIPS perspective more strongly reject the notion of keeping business as usual as long as tourists keep coming, than do the other perspectives (S21). This openness to change documented in this study shows there is potential for productive stakeholder deliberation and collaboration in the context of developing strategies for sustainable mountain development. Moreover, there is an agreement between WIPS and Conservative Ecologists that enterprises should take responsibility for ensuring adherence to environmental regulations (S38). Despite these points of alignment, we found little evidence that the Conservative Ecologist social perspective encompasses trusting the industry with adherence to ecological principles without being forced to by law and by the lobby of ecologists. Indeed, such lack of trust is well reflected in public discussions (SWI, 2000). Consequently, in our study, the Conservative Ecologists tended to not oppose to the statement that 'the lack of snow is just an excuse for using ASP to prolong the ski season' (S1 +1); a statement with which the WIPS vehemently disagreed (S1 -5), disqualifying it as e.g. "unfair" and "absolutely ridiculous" (Stakeholders 12, 23 - SI Table 4). These observations imply that although the social perspectives have a degree of common ground (including regarding the importance of sustainability), this common ground may not be intuitively obvious and may not be believed, and so efforts to engage with stakeholders superficially risk provoking agitation/mistrust (and by extension inadvertently and unproductively narrowing the scope for creative problem-solving).

The above illustrates how differences in the value systems amongst the three social perspectives could hinder the alignment of the stakeholders for a universal strategy of mountain region development, especially if the process by which that alignment is sought is not carefully managed. This suggests it is not practical to pursue a 'one size fits all' solution to problems associated with sustainable mountain region development. Instead, the data gathered in this study suggest that a decentralized, stakeholder-focused approach with mountain regions implementing their own preferred measures (according to the prominent local values, and within the constraints of the agreed upon principles of sustainable development at the national level) would have more merit.

Such a procedure, though difficult, could be implemented in Switzerland given its established decentralized structure. Switzerland has been practising heterogeneity of cultures historically, and decentralized approaches are often used to account for differences in values and cultures. The success of this procedure requires quality of communication between stakeholders. The insights provided in this study may assist stakeholders to engage in constructive discussions that may lead to promising policies.

Beyond Switzerland, the results should be in many ways universally applicable. The importance of understanding attitudes to engage in better communicative strategies to achieve good public policies is of international significance. Many nations are facing locally diverse, climate change-driven sustainable development challenges in which each the economy, the environment, and society will be affected. Overcoming these challenges is going to require creativity and compromise and using the full 'solution space' available. As such, we recommend an increase in stakeholder communication and regular stakeholder analysis, so that the evolution of stakeholder perspectives overtime can be actively utilised in pursuing sustainable development.

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